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ABSTRACT

This investigation of formaldehyde exposure in school laboratories, where its principal source is from preserved biological specimens, was undertaken because of concern over exposure levels reported in the literature. Information was obtained in two ways. A limited survey of schools was conducted to determine extent of students' use of preserved specimens. Various producers of preserved specimens were also surveyed to obtain information on sales, general industry practices, and availability of substitutes. Air measurements in classrooms where dissection was underway and specific information on specimens used, class size, and general ventilation in school laboratories/classrooms were obtained in another study. Among the results reported are findings that use of formaldehyde-preserved specimens exposes students/teachers to formaldehyde levels in excess of background exposure and that industry, aware of the toxicity problem, has developed new-technology packing media which significantly reduces such emissions. (JN)

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INVESTIGATION OF EXPOSURE TO FORMALDEHYDE FROM PRESERVED BIOLOGICAL SPECIMENS

STATUS REPORT

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CONTRIBUTORS TO THE BRIEFING PACKAGE

The active support of the Chicago, New York, and San Francisco field offices and laboratories, and the assistance of the Buffalo, Charleston, and Milwaukee resident investigators, contributed to the timely completion of this effort.

The laboratory work essential to this package was contributed to by Dave Baker, Sumar Dugar, Connie Hoheisel, Al Nero, Warren Porter, Raymond Harris, Robert Sheilds, and the late Gale Wyer.

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The complete report included Tab A: "Preliminary Economic Report on the use of Formaldehyde in School Laboratories," by David Pomeroy, and Tab B: a series of internal memoranda on the subject of formaldehyde in biological specimens and a "Protocol for Air Sampling of Formaldehyde in High School and College Teaching Laboratories." Since Tab A/B appendices were not reproducible, only the report itself is included.

ISSUE

Does the use, in school laboratories, of biological specimens preserved in formaldehyde, subject students and teachers to risks of injury or illness which the Commission should seek to reduce?

BACKGROUND

Concern over the adverse effects on human health of formaldehyde including its properties as a strong irritant, sensitizer, and its carcinogenic potential, have led the Commission staff to investigate consumer exposure to products which contain, and are capable of releasing, formaldehyde.

This investigation of formaldehyde exposure in school laboratories, where its principal source is from preserved biological specimens, was undertaken because of concern over exposure levels reported in the literature. A previous study by Schwartz (1) reported air levels of formaldehyde in a biology laboratory at New York University where students were dissecting preserved cats. Formaldehyde levels ranged from 2.8 ppm in classroom air, to 14.1 ppm in the students' breathing zone. Measurements in an anatomy laboratory of a German university (2) showed levels of formaldehyde ranging from 0.4 ppm to 6 ppm. These studies indicate that use of the biological specimens, preserved in formaldehyde, might be resulting in exposures of concern for teachers and students.

STUDIES UNDERTAKEN

The staff obtained information on formaldehyde exposure in school laboratories in two ways:

- A limited survey of schools was conducted by Economics to determine the extent of students' use of preserved specimens. Various producers of preserved specimens were also surveyed to obtain information on sales, general industry practices, and availability of substitutes.

- A study by the field offices and laboratories provided air measurements, in actual classrooms where dissection was underway, and specific information on specimens used, class size, and general ventilation in the school laboratory/classroom.

Both the Economic Analysis and the Field Offices surveys identified an emerging use of new-technology, low-formaldehyde specimens. Subsequently, the Health Sciences Laboratory undertook a study to compare formaldehyde emissions from the new-technology specimens with emissions from specimens processed in the traditional manner.

PRESERVATION AND PROCESSING OF SPECIMENS

Formaldehyde is the fixative of choice for animal specimens. Animal specimens used for teaching purposes are either "pickled" by immersion in the formaldehyde solution, or "embalmed" by injection of the formaldehyde solution directly into the body cavity or circulatory system. An estimated 75 percent of all specimens are embalmed. Formaldehyde is uniquely able to penetrate

and preserve specimens rapidly without excessive hardening and shrinkage of tissues. Ten percent formalin (3.7 percent formaldehyde in water) traditionally has been used as a biological tissue fixative. The fixative solution may contain, in addition to formaldehyde and other aldehydes, water, phenol and alcohol.

After being "fixed," specimens were traditionally packed in a 3.7 percent formaldehyde solution, and shipped to teaching laboratories in "pails" or "barrels". The preservation process retards spoilage, permitting ample time for transport of the specimens and for students to work on specimens for the weeks or months necessary to the learning process.

Student and teacher dislike of formaldehyde's disagreeable odor, and its irritation of the eyes and mucous membrane, as well as the recently published information on formaldehyde carcinogenicity, have prompted many producers to provide specimens which emit less formaldehyde. Several suppliers have developed after-treatments to reduce the formaldehyde emitted from the specimens in the classroom. After the specimens have initially been fixed in a formaldehyde solution, they receive an after-treatment. Some firms wash the specimens in running water to remove the formaldehyde. After washing out some of the formaldehyde, specimen suppliers immerse these "low odor" specimens in low or non-formaldehyde packing solutions of varying composition.

Other firms do not wash the specimens, but transfer the preserved specimens directly from the formalin solution to the new-technology packing media. The formulations of these preservative media are proprietary, but most contain ethylene glycol, various bacteriostatic agents, glycerins, and parabens (common ingredients in skin moisturizers) to keep the exposed tissues from drying out. Specimens are stored in the preservative media for varying periods of time prior to shipment to the schools.

Some suppliers offer customers a choice of specimens packed either in the traditional formaldehyde solution or in the new-technology preservative media. Other firms offer only new-technology specimens, or will furnish formaldehyde-packed specimens only on "special order".

In addition to the traditional bulk pack of specimens in pails or barrels of solution, specimens also are available in individual vacuum-packed non-permeable plastic film bags. These are known as "dry packed" and have a small amount of preservative solution present. New-technology preservative/storage solutions are also supplied in bulk or as "concentrate" to school laboratories to moisten and maintain the preserved specimens when they are studied and stored for extended periods.

It appears that the development of alternative technologies for tissue fixation and preservation, is in a period of flux as companies attempt, with varying efficiencies, to reduce the formaldehyde emissions from preserved biological specimens.

ECONOMIC PROFILE OF PRODUCERS AND DISTRIBUTORS

Economic Analysis has determined (Tab A) that, of the approximately 50 firms producing and selling preserved biological specimens, there are five

major firms accounting for 57 to 74 percent of estimated industry annual sales. These firms each offer some or all of their specimens in new technology preservatives.

Annual sales of preserved specimens are estimated to account for $6.5 - $8.5 million. Preserved specimens (which also include items not preserved in formaldehyde, e.g. plants and insects) generally represent a small portion of a company's total sales. All of the companies identified by Economic Analysis offer other laboratory equipment and supplies, educational aids, geological minerals, and nonbiological displays.

Specimens packed in new-technology media are 3-33 percent more expensive than traditional formalin-packed specimens. Increased costs are primarily because new technology preservatives are petroleum based and involve increased handling and labor costs.

Economic Analysis has noted that there was a significant trend by manufacturers and sellers to offer preserved biological specimens which have been washed and/or packed in low or non-formaldehyde solutions. Economic Analysis also noted that substitute methods of instruction - models, kits, charts - are widely available.

USE OF PRESERVED SPECIMENS IN SCHOOL CURRICULUMS

On the basis of a contractor survey, Economic Analysis estimates that a significant proportion of school students, perhaps 13 percent or approximately 7.6 million students, may be exposed to preserved specimens for dissection during each school year. A. D. Little conducted a limited national survey of elementary, junior, and senior high schools and public and private colleges and universities to identify the use of formaldehyde in their curriculums. While dissection of specimens at the elementary school level was very limited, the dissection of preserved specimens increased in the junior high and senior high curriculums. Twenty-four percent of the total junior and senior high school enrollment surveyed dissected preserved specimens. In both junior and senior high schools, laboratory dissection classes were scheduled daily for extended periods of weeks and months. The advanced biology and physiology courses in senior high schools involved dissection for 6-8 months of the 10 month school year. Some ecology and oceanographic courses involved the student in actual collection and preservation of specimens. Ten percent of the total college level enrollment was exposed to preserved specimens for dissection; however, college students are exposed for greater periods of time than high school students.

Economic Analysis concluded that a significant proportion of school students are exposed to formaldehyde through dissection of preserved biological specimens in the school laboratory. Preserved specimens are also available for observation in the elementary, secondary, and college level classes. These specimens are in fluid-filled glass jars; both new-technology and formalin packing solutions are used. Observation specimens may contribute small amounts of formaldehyde to the general classroom air on a continuous basis; however, there is no measurement data to confirm this.

EXPOSURE

The Field Offices and Laboratories measured formaldehyde vapor levels in 26 high school and college teaching laboratories, where preserved biological specimens were being dissected. Air sampling was conducted in the breathing zones of students and elsewhere in the classroom as well as in the classroom before dissection, elsewhere in the building and outside. The study (Tab B) revealed:

- Levels of formaldehyde in the breathing zone of students dissecting a specimen, and elsewhere in the classroom, were significantly higher than the background levels found elsewhere in the school or outdoors.

- In several classrooms, where formalin-packed specimens were in use the levels of formaldehyde in the breathing zones of students, and elsewhere in the classroom, were well within the levels demonstrated to cause adverse health effects in controlled experiments and industrial and residential studies.

- Levels of formaldehyde in the student's breathing zone were reduced when new-technology specimens were used, or when specimens were washed.

- Open windows and other active ventilation appeared to lower the levels of formaldehyde in the breathing zone and in classroom air.

There were many variables in the classroom situation (e.g. size and type of specimen, number of specimens in the classroom, size of classroom, rate of ventilation) which may have influenced the measured levels of formaldehyde. In order to more clearly assess whether use of the new-technology specimens would reduce formaldehyde exposure, Health Sciences Laboratories conducted a controlled laboratory study (Tab B). The study evaluated the rate of release of formaldehyde from preserved specimens of frogs and sharks packed in formalin versus those packed in a new-technology packing media. The study confirmed the observation noted in the classroom measurements, that "aftertreated" or new-technology specimens have lower rates of formaldehyde release than the traditional formalin-packed specimens.

The laboratory study further showed that the amount of formaldehyde released into the air was generally related to the amount of formaldehyde present in the packing media and the size of the specimen. Formaldehyde in the new-technology packing media may be due to diffusion from the specimen, residual liquid on the specimen, or a small amount of formaldehyde intentionally added to the media. The samples from a firm which washed the specimens prior to packing them in a glycol based media consistently gave the lowest values. A washing process would appear to assist in reducing the ultimate formaldehyde emissions, especially in the case of the larger embalmed specimens where residual formalin fixative would be present in the body cavity.

Based on the measurements in the classroom and on the controlled laboratory study, Health Sciences concludes that several factors influence the extent of student exposure to formaldehyde:

- concentration of formaldehyde in specimen packing media; e.g. use of new-technology specimens
- washing of specimen;
- ventilation of classroom;
- size of classroom, number of specimens under dissection; and
- size of specimen being dissected.

DISCUSSION AND CONCLUSIONS

Use of preserved biological specimens in the school laboratory classroom exposes students and teachers to formaldehyde levels in excess of background exposure. Students dissecting specimens without after-treatments can be exposed to breathing zone levels of formaldehyde in excess of 1 ppm. The extent of formaldehyde exposure is dependent upon many variables, and an average student exposure cannot be characterized adequately from the small number of measurements presently available. However, students, because of their age and stage of development, may be more sensitive than is the general population, to the irritant, allergic, and sensitization effects, and may be at a higher risk of developing cancer from exposure to formaldehyde. Numerous scientists and groups of scientists have recommended that, based on information now available, human exposure to formaldehyde should be minimized to the extent practicable.

Industry appears to be aware of the toxicity problems presented by formaldehyde and major suppliers have developed new-technology packing media which significantly reduces formaldehyde emissions; however, specimens packed in the new-technology media are slightly more expensive. This increased cost appears to be related to labor cost from multiple handling of the specimens. No adequate substitute for formaldehyde in specimen fixation has been yet identified.

The exposure of teachers and students can be reduced through purchase of specimens packed in new-technology media, by aggresssive washing of traditional formalin-packed specimens, and by providing a high level of ventilation (open windows and doors, high capacity exhaust fans, etc.) Assuring adequate ventilation may be difficult in some schools where the classrooms have no windows, or where the windows were designed not to open. Modifications to the existing ventilation system may be costly. Facilities and personnel may not be available to wash the specimens in the schools.

RECOMMENDATIONS

The staff notes that manufacturers and suppliers of preserved biological specimens, in response to existing market place demands, have begun to develop alternatives to traditional formalin preservation and storage media. The staff recommends that discussions be initiated with organizations such as the National Science Teachers Association to inform them about the availability of new-technology specimens, and the various other means by which to reduce student and teacher exposure to formaldehyde. The staff proposes to accomplish these outreach efforts, during FY82, through the Children's Chemical Hazards project of the Chemical Hazards Program. The project has an overall objective to increase the awareness of school chemical hazards and school laboratory safety.

REFERENCES

1) Schwartz, G. A report on the Investigation of the formaldehyde concentrations found in Biology Department Teaching Laboratories at New York University. ERC Outreach 1 (2): 4-6, 1980 (February).

2) Rader, J. Irritative effects of formaldehyde in laboratory halls. Analytical and experimental investigators. Dissertation from Inst. Pharmacol. Toxicol.: U. Wuerzbug. 1974.